REMOVAL OF HEAVY METALS FROM INDUSTRIAL WASTEWATER USING FRUITS PEEL AS A LOW-COST BIO-ADSORBENT

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Untuk menghilangkan logam berat dari air kumbahan industri, proses rawatan konvensional yang biasanya digunakan mempunyai beberapa kelemahan. Kaedah penyerapan adalah salah satu proses alternatif untuk menghilangkan logam berat. Walau bagaimanapun, harga bagi penggunaaan "activated carbon" sebagai penyerap adalah mahal. Salah satu penyelesaian yang disyorkan adalah dengan menggunakan kulit buah sebagai bio-penyerapan. Kajian ini bertujuan untuk menentukan kapasiti optimum kulit pisang, mangga dan oren sebagai bio-penjerapan dalam merawat air kumbahan industri. Selain itu, ia juga bertujuan untuk membandingkan kesan dari segi masa,pH awal dan suhu dalam penyingkiran logam berat. Selain itu, kajian ini akan menganalisis kajian penjerapan dari segi "dosage", tahap pH, suhu dan masa. "Langmuir adsorption model" disahkan dengan cara plot linear Ce / qe terhadap Ce. Hasilnya menunjukkan bahawa kapasiti optimum penyerapan untuk penyerap oren, pisang dan mangga mengurai sekitar 1.2 gram, 0.8 gram dan 1.6 gram dengan tahap pH terbaik 4 untuk oren dan mangga manakala pH 2 untuk pisang. Suhu tidak mempengaruhi kecekapan penjerapan dalam lingkungan 29°c hingga 49°c dan untuk kesan masa,penyerap menyerap dengan cepat pada 20 minit pertama dan secara beransur-ansur meningkat dan kekal stabil selepas beberapa minit. Kajian ini mendedahkan bahawa kulit buah-buahan terbaik yang boleh digunakan sebagai penyerap adalah kulit oren kerana ia dapat menyerap banyak ion plumbum berbanding dengan dua buah yang lain.

ABSTRACT

In order to remove heavy metal from industrial wastewater, the conventional treatment processes that usually been use have several disadvantages. Adsorption method is the alternative process to remove heavy metal. However, the cost of using activated carbon as an adsorbent is expensive. One of the recommended solutions is to use fruits peel as a bio-adsorbent. This study aims to determine the optimum capacity of banana, mango and orange peel as bio-adsorption in treating industrial wastewater. Besides that, it also aims to compare the effect of contact time, initial pH and temperature in the removal of heavy metals. Other than that, this study will analyze the batch adsorption study base on dosage, pH level, temperature and contact time. Langmuir adsorption model was used which is confirmed by a linear plot of Ce/qe against Ce. The results showed that optimum adsorption capacity for orange, banana and mango peel adsorbent is around 1.2gram, 0.8gram and 1.6gram respectively with the best pH level of 4 for orange and mango meanwhile pH 2 for banana. The temperature does not influence the efficiency of adsorption in the range of 29ºc until 49ºc and for the effect of contact time, the adsorbent absorbs rapidly at the first 20 min and gradually increase and remained stable after a few minutes. This study revealed that the best fruits peel that can be used as an adsorbent is orange peel as it can absorb many lead ions compare with the other two fruits peel.

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LIST OF SYMBOLS

mg/l	Milligram per litre
^{o}c	Degree Celsius
ppm	Parts per million
mol/l	Molar concentration per litre
mm	Millimetre
L/mg	Litre per milligram
mg/g	Milligram per gram
g	Gram
q_e	Amount of adsorption at equilibrium
C_o	Initial concentration
C_e	Equilibrium concentration
V	Volume of solution
X	Weight of adsorbent
b	Constant related to the energy
Q_o	Mass of adsorbed solute required to saturate a unit mass of adsorbent
R_L	Equilibrium parameter

LIST OF ABBREVIATIONS

Cu	Copper
Pb	Lead
Cd	Cadmium
Hg	Mercury
As	Arsenic
Cr	Chromium
Se	Selenium
Ni	Nickel
Ag	Silver
Zn	Zinc
Fe	Iron
AAS	Atomic adsorption spectrophotometry
BOD	Biochemical oxygen demand
COD	Chemical oxygen demand
WHO	World Health Organization
DOE	Department of Environment
-OH	Hydroxide
HNO_3	Nitric acid
NaOH	Sodium hydroxide

CHAPTER 1

INTRODUCTION

1.1 Introduction

Water is valuable natural resources to human, all living things and a healthy environment. Human needs water to complete their routine in daily life. Water also has been used in industrial in order to make sure their plants are running well instead as the main resource for drinking. Water is a transparent fluid which produces the streams, lakes, oceans, and rain, and is the principal constituent of the fluids of organisms. As a chemical compound, a water molecule contains one oxygen and hydrogen atoms that are related through covalent bonds. All living things will not survive without water for a long term and same goes to the industry which is it cannot be functional without existing of water. Besides, water plays an important role in the population growth and rapid development as the clean water resources needed as the pre-requisite in the existing of remain population.

Nowadays, because of the rapid growth of the industrial sector, the productions of heavy metal wastes into the water have been increasing day by day. Heavy metal pollution in the environment is one of the serious pollutions that occur globally. In recent years, ecological and global public health concern associated with environmental by these heavy metals has increased. The discharge of heavy metals from various sources especially from industry and agricultural into the aquatic ecosystem can accumulate in living tissues causing various disease and disorders. The industrial effluents which contain different derivatives of heavy metal such as copper, lead, cadmium, mercury, arsenic, chromium, selenium, nickel, silver, and zinc are continuously discharging to the ecosystem and producing a significant toxic on the aquatic environment. These heavy metals will persist in the environment since they

cannot be degraded and finally reach to the human food chain and result in the health problems.

Among these heavy metals, lead and copper is the most common pollutants found in the industrial effluents (Kahraman & Erdemoglu, 2008). The excess for lead in the water poses severe health risks to humans such as cancer, reproductive system disorders, high blood pressure, heart disease and skin disease (Abbaszadeh et al., 2018). Besides that, although copper is an essential present element the high level of it can cause harmful effects to human health (Kahraman & Erdemoglu, 2008). In most of the wastewaters, the concentration of heavy metals present is much larger than the safe permission limit. Therefore, the removal of heavy metal is one of the most important environmental issues that need to be solved.

In order to remove the heavy metal, there are several treatment processes that can be done such as chemical precipitation, membrane filtration, ion exchange, adsorption, co-precipitation and extraction (Bhatnagar et al., 2010). Among these treatment processes, the adsorption method is the most effective method to remove the heavy metals as it offers some benefit such as easy to operate, do not require any high skilled labour, environmentally safe and the process is non-destructive so that contaminants can be separated and recycled (Ahmad & Danish, 2018). The main parameter for doing adsorption is the adsorbent for removal and extraction purpose. The adsorbent that has been used is usually activated carbon as it has known for the effectiveness in removing heavy metal especially copper and lead from wastewater. Recently the researches have been made to use the nature adsorbent to replace the activated carbon.

1.2 Problem Statement

In order to remove the heavy metal, several treatment processes can be done such as chemical precipitation, membrane filtration, ion exchange, co-precipitation, and extraction. However, these methods proved either inefficient or expensive in case of low concentration (1-100mg/l) of heavy metals prevailing in the environment and generate a huge amount of sludge which is difficult to be disposed of (Ahmad & Danish, 2018). Other than that, most of these methods are not suitable for a small-scale industry which affects the operational cost and excess amount of chemical usage

Because of that, adsorption method is been select as an alternative to removing the heavy metal due to their low cost, easy to operate, do not require any high skilled labour, environmentally safe and the process is non-destructive so that contaminants can be separated and recycled. However, the use of commercial activated carbon as an adsorbent makes the adsorption process expensive. The high demand for activated carbons in other advanced application make in increasing their cost.

Therefore, in order to decrease the cost of the adsorbent, many kinds of research have been conducted to find the low cost of adsorbent with the high metal binding which is by using agricultural waste. The agricultural waste has been developed as it shows some advantages as it was cheap, readily available, low-cost, simple to use and environment friendliness. The agricultural waste such as chitosan, chitin, sugarcane bagasse, apple and orange juice residue, banana, wheat straw, rice husk, tea waste has been investigated as bio-sorbent for removal of heavy metals (Ahmad & Danish, 2018). Fruits peel is one of the agricultural wastes that can be used as bio-adsorbent. While these materials are considered wastes with a low or no economic value, and usually present removal and disposal, this transformation toward bio-adsorbent material add economic value and also help on reducing the disposal costs (Romero-Cano, 2016).

In this study, banana, mango, and orange peel have been select in order to produce bio-adsorbent though environment-friendly process. The residues of this fruit can be processed and convert it to be adsorbents because it's had a large surface area, high swelling capacities, and excellent mechanical strength and is convenient to use and

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